HUAWEI EM820W HSPA+ PC Embedded Module

Hardware Guide

Issue 01

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About This Document

History

Version	Date	Chapter	Descriptions
01	2010-12-31		Creation

Contents

Tables

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1 Introduction

1.1 Overview

This document describes the hardware application interfaces and air interfaces that are provided when the Huawei EM820W HSPA+ PC Embedded module (hereinafter referred to as the EM820W module) is used.

This document helps you to understand the interface specifications, electrical features, and related product information of the EM820W module. To facilitate its use in different fields, relevant development guides document are also provided with the module, which can be obtained through Huawei website.

2 Overall Description

2.1 About This Chapter

This chapter gives a general description of the EM820W module and provides:

- Function Overview
- Circuit Block Diagram
- Application Block Diagram

2.2 Function Overview

Table 2-1 Feature

Feature	Description
Working bands	GSM/GPRS/EDGE 850/900/1800/1900 (MHz) HSPA+/HSUPA/HSDPA/WCDMA 2100/1900/900/850 (MHz)
Working temperature	Normal working temperature: –10°C to +55°C
	Extreme working temperatures: –20°C to –10°C and +55°C to +70°C
Ambient temperature for storage	–40°C to 85°C
Power voltage	3.3 V±9 %(3.3 V is recommended)
AT commands	See the HUAWEI EM820W HSPA+ PC Embedded Module Software Guide Specification.
Application interface (52pin Mini PCI-E interface)	One standard Subscriber Identity Module (SIM) card interface (3 V or 1.8 V)
	USB 2.0 (high speed)
	WAKE#: Wake up signal

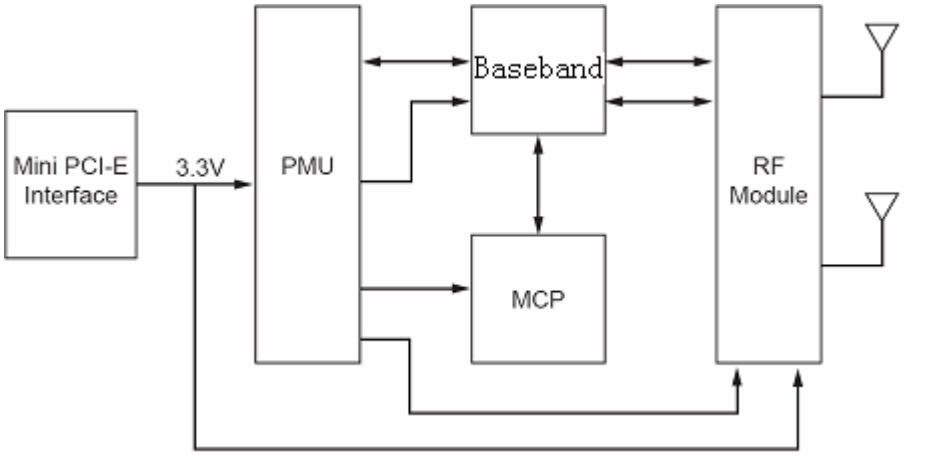
Feature	Description
	W_Disable#: for turning on/off the RF signal.
	LED_WWAN#: Active-low LED signal indicating the state of the card
	Power Interface
SMS	New message alert, receiving and sending text messages
	Management of text messages: read messages, delete messages, storage status, and message list
	Support for the protocol data unit (PDU) mode
Data services	GSM CS: 9.6/14.4 kbps
	GPRS/EDGE: Multi-slot Class 12, Class B
	WCDMA CS: UL 64kbps/DL 64kbps
	WCDMA/HSDPA PS: UL384kbps/DL3.6Mbps, HSDPA Category 6, 8, 9, 10, 12, 14
	HSPA+ Rel7
Physical features	Dimensions (L × W × H): 50.95 mm × 30 mm × 4.5 mm Weight: < 15 g
Certification information	Restriction of the use of certain Hazardous Substances (RoHS), European Conformity (CE), Federal Communications Commission (FCC)

2.3 Circuit Block Diagram

Figure 2-1 shows the circuit block diagram of the EM820W module. The application block diagram and major functional units of the EM820W module contain the following parts:

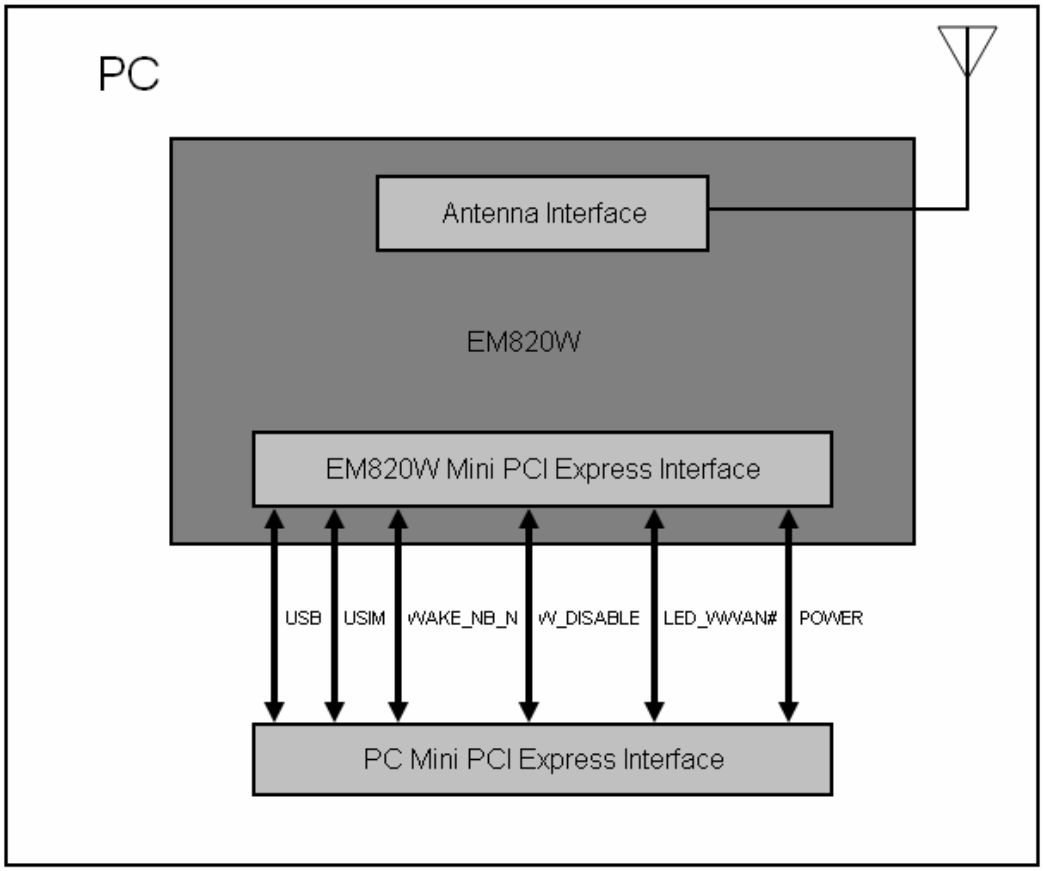
- Mobile data modem
- Power management
- Multi-chip package (MCP) memory
- Radio frequency (RF) transceiver
- RF front-end modules
- Receive filter

Figure 2-1 Circuit block diagram of the EM820W module



2.4 Application Block Diagram

Figure 2-2 Application block diagram of the EM820W module



3 Description of the Application Interfaces

3.1 About This Chapter

This chapter mainly describes the external application interfaces of the EM820W module, including:

- Mini PCI Express Interface
- Power Sources and Grounds
- Power Supply Time Sequence
- USB Signals
- USIM Signals
- W_DISABLE# Signal
- LED_WWAN# Signal
- WAKE_NB_N Signal
- NC Pins

3.2 Mini PCI Express Interface

The EM820W has a standard Mini PCI Express interface, which consists of several major signals, as shown in the following table.

Table 3-1 Pin definitions of the Mini PCI-E Interface

Definition of the EM820W Mini PCI Express pins				
Pin No.	**Mini PCI Express Standard Description**	**HUAWEI Pin Description**	**Additional Description**	**Direction to Module**
1	WAKE#	WAKE_NB_N	Open collector active low signal. This signal is used to wake up the host.	Output

Definition of the EM820W Mini PCI Express pins				
Pin No.	**Mini PCI Express Standard Description**	**HUAWEI Pin Description**	**Additional Description**	**Direction to Module**
2	3.3Vaux	VCC_3V3	3.3 V DC supply rails from the PC side.	Input
3	COEX1	NC	Not connected.	-
4	GND	GND	Mini Card ground.	-
5	COEX2	NC	Not connected.	-
6	1.5 V	NC	Not connected.	-
7	CLKREQ#	NC	Not connected.	-
8	UIM_PWR	UIM_PWR	Power source for the external UIM/SIM card.	Output
9	GND	GND	Mini Card ground.	-
10	UIM_DATA	UIM_DATA	External UIM/SIM data signal.	Input/output
11	REFCLK-	NC	Not connected.	-
12	UIM_CLK	UIM_CLK	External UIM/SIM clock signal.	Output
13	REFCLK+	NC	Not connected.	-
14	UIM_RESET	UIM_RESET	External UIM/SIM reset signal.	Output
15	GND	GND	Mini Card ground.	-
16	UIM_Vpp	NC	Not connected.	-
17	Reserved	NC	Not connected.	-
18	GND	GND	Mini Card ground.	-
19	Reserved	NC	Not connected.	-
20	W_DISABLE#	W_DISABLE_N	For ending the wireless communications.	Input
21	GND	GND	Mini Card ground.	-
22	PERST#	NC	Not connected.	-
23	PERn0	NC	Not connected.	-
24	3.3Vaux	VCC_3V3	3.3V DC supply rail from the PC side.	Input

Definition of the EM820W Mini PCI Express pins				
Pin No.	**Mini PCI Express Standard Description**	**HUAWEI Pin Description**	**Additional Description**	**Direction to Module**
25	PERp0	NC	Not connected.	-
26	GND	GND	Mini Card ground.	-
27	GND	GND	Mini Card ground.	-
28	1.5 V	NC	Not connected.	-
29	GND	GND	Mini Card ground.	-
30	SMB_CLK	NC	Not connected.	-
31	PETn0	NC	Not connected.	-
32	SMB_DATA	NC	Not connected.	-
33	PETp0	NC	Not connected.	-
34	GND	GND	Mini Card ground.	-
35	GND	GND	Mini Card ground.	-
36	USB_D-	USB_D-	USB signal D-.	Input/output
37	GND	GND	Mini Card ground.	-
38	USB_D+	USB_D+	USB signal D+.	Input/output
39	3.3Vaux	VCC_3V3	3.3V DC supply rail from the PC side.	Input
40	GND	GND	Mini Card ground.	-
41	3.3Vaux	VCC_3V3	3.3V DC supply rail from the PC side.	Input
42	LED_WWAN#	LED_WWAN	Active-low LED signal indicating the state of the card.	Output
43	GND	GND	Mini Card ground.	-
44	LED_WLAN#	NC	Not connected.	-
45	Reserved	NC	Not connected.	-
46	LED_WPAN#	NC	Not connected.	-
47	Reserved	NC	Not connected.	-
48	1.5 V	NC	Not connected.	-
49	Reserved	NC	Not connected.	-

Definition of the EM820W Mini PCI Express pins				
Pin No.	**Mini PCI Express Standard Description**	**HUAWEI Pin Description**	**Additional Description**	**Direction to Module**
50	GND	GND	Mini Card Ground.	-
51	Reserved	NC	Not connected.	-
52	3.3Vaux	VCC_3V3	3.3V DC supply rail from the PC side.	Input

3.3 Power Sources and Grounds

The PCI Express Mini Card provides two power sources: one is 3.3 Vaux (+3.3 Vaux) and the other is 1.5 V (+ 1.5 V). For the EM820W, however, +3.3 Vaux is the only voltage supply that is available. The input voltage is 3.3 V±9%, as specified by PCI Express Mini CEM Specifications 1.2.

Table 3-2 Power and ground specifications

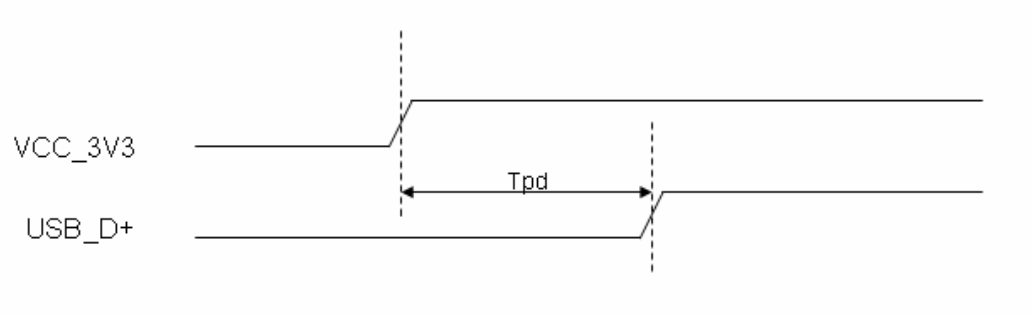
Name	Pins	Minimum	Type	Maximum
VCC	2, 24,39, 41, and 52	3.0 V	3.3 V	3.6 V
GND	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, and 50	0 V		

NOTE
To minimize the RF radiation through the power lines, it is suggested to add ceramic capacitors of 10pF and 100nF in the ground beside the Mini PCI Express connector on the host side.

3.4 Power Supply Time Sequence

Figure 3-1 shows the PCIE with 3.3 V voltage and USB D+ power supply time sequence.

Figure 3-1 HUAWEI EM820W power supply time sequence.



Parameter	Remarks	Time(Nominal value)	Unit
Tpd	Power Valid to USB D+ high	3.24	sec

3.5 USB Signals

The EM820W is compliant with USB 2.0 specification. It supports full-speed (12 Mbit/s) and high-speed (480 Mbit/s) modes when acting as a peripheral and supports low-speed, full-speed, and high-speed modes when acting as a host. The USB 2.0 specifications allow peripherals to support any one or more of these speeds. To ensure best performance, the PC USB host controller should support high-speed mode when using the EM820W USB high-speed mode.

Table 3-3 USB pins

Name	Pin	Description	Direction to Module
USB D-	36	USB data signal D-	Input/output
USB D+	38	USB data signal D+	Input/output

NOTE
To minimize the RF radiation through the PCI-E interface, you can add a 33 pF ceramic capacitor in the ground on every pin of the PCI-E on the host side except USB D+/D-.

The USB interface is powered directly from the 3.3 V supply. The USB input/output lines are compatible with the USB2.0 3.3 V signal specifications.

Table 3-4 USB signal DC characteristics

VOHmin	VOLmax	VIHmin	VILmax
2.8 V	0.3 V	2 V	0.8 V

The high-speed signal characteristics are in accordance with the Eye Pattern Templates of the USB2.0 signal specification.

3.6 USIM Signals

The USIM is a smart card for UMTS/GSM cellular applications. The USIM provides the required subscription information to allow mobile equipment to attach to a GSM or UMTS network. The USIM also provides the subscriber's verification procedures as well as authentication methods for network authentication during the process of attaching to a network.

Table 3-5 USIM pins

Pin	Name	Description	Direction to Module
8	UIM_PWR	Power source for the external UIM/SIM.	Output
10	UIM_DATA	External UIM/SIM data signal.	Input/output
12	UIM_CLK	External UIM/SIM clock signal.	Output
14	UIM_RESET	External UIM/SIM reset signal.	Output

NOTE
It is recommended that the SIM card is inserted only after the power supply of the module is disconnected; otherwise the SIM card may get destroyed.

3.6.1 USIM Interface Schematic Reference

There is no SIM card interface circuit in the EM820W module, and users need to add the USIM interface circuit. Figure 3-2 shows the definition of interface signals and the typical USIM interface schematic.

Figure 3-2 USIM interface schematic on PC

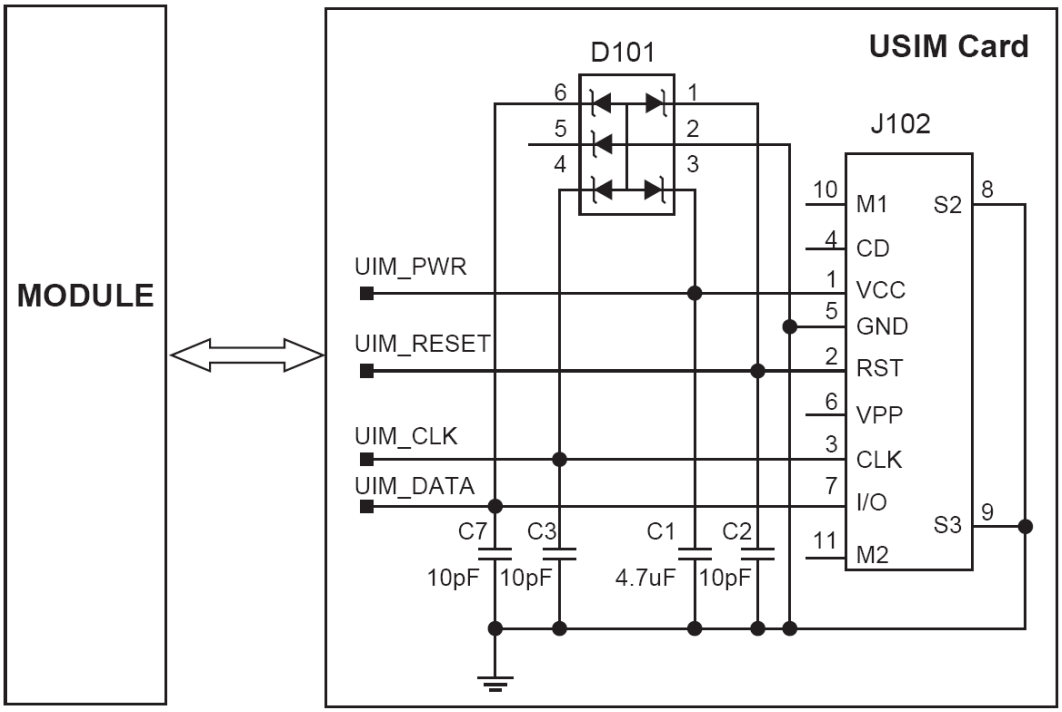
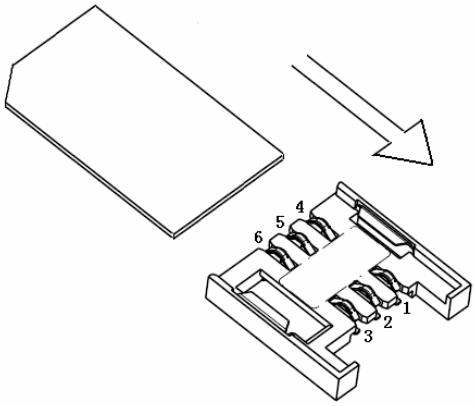


Figure 3-3 Pin definition of the SIM card Socket



pin1:	SIM_VCC	pin4:	GND
pin2:	SIM_RESET	pin5:	NULL
pin3:	SIM_CLK	pin6:	SIM_DATA

3.6.2 Design Guide

The USIM signals are connected to the Mini PCI Express card connector (the card edge connector) and pass through an EMI filtering and ESD protection circuit on the

module board before entering the EM820W processor. There is also an EMI filtering and ESD protection circuit between the SIM card interface and the Mini PCI interface on the user's board.

- Power supply

  The SIM card interface is powered by an internal LDO regulator of EM820W. The default value of this regulator is 2.85 V. The power of the regulator is programmable in the range of 1.5 V to 3.05 V and is expected to be set to 3.0 V or 1.8 V.

- Modem signals

  After a power-on or reset, the USIM signals are activated to detect if a SIM card is present and to initialize it if it exists. Once a SIM card has been detected and initialized, the interface is always on. However, the clock signal is only activated when data is actually being transmitted. The USIM signals from the module are connected to the level translators, and then to the Mini Card host connector.

  - The UIM_DETECT pin is optional, depending on whether this function is required.
  - For UIM_DATA, it does not need to add a pull-up resistor, because it has been pulled up to UIM_PWR with a 15 kΩ resistor on the module, in compliance with the ISO/IEC 7816-3.
  - For UIM_PWR, it is recommended to add an additional decoupling capacitor ranging from 1uF to 10uF, and to place a 10pF capacitor on each of the signals such as UIM_RST, UIM_CLK and UIM_DATA.

  These levels exceed those required in ISO/IEC 7816-3.

- SIM signals

  The following data is taken from the ETSI standard Specification of the 3 Volt Subscriber Identity Module - Mobile Equipment (SIM-ME) interface (GSM 11.12 version 4.3.1).

Table 3-6 SIM RST requirements

RST	Minimum	Maximum
V_{IL}	0	0.2Vcc
V_{IH}	0.7Vcc	Vcc

Table 3-7 SIM CLK requirements

CLK	Minimum	Maximum
V_{IL}	0	0.2Vcc
V_{IH}	0.7Vcc	Vcc

Table 3-8 SIM IO requirements

IO	Minimum	Maximum
V_{IL}	0	0.4
V_{IH}	0.7Vcc	Vcc
V_{OL}	–0.3	0.2 Vcc
V_{OH}	0.7 Vcc	Vcc+0.3

NOTE

The V_{OL}max of 0.45 V for the output is specified at an output current of 3 mA whereas the V_{IL}max of 0.4 V for the SIM IO input is specified at an input current of 1 mA. With the smaller current drive, the output voltage would be driven lower than the stated maximum value.

- ESD protection

  Since the SIM is a CMOS device, ESD protection devices should be placed near the SIM connector to provide protection before connecting to the module. In addition, all the SIM interface signals should be bypassed with a 10 pF capacitor.

  The used ESD device (PESD3V3L5UY, NXP) in Figure 3-2 is a low capacitance 5-fold ESD protection diode arrays in SOT363 package.

- Clock frequency

  The SIM must support clock frequencies between 1 MHz and 4 MHz. (The Mini Card can be programmed to generate a clock of 1.625 MHz, 2.6 MHz, or 3.25 MHz.)

- Routing recommendations

  The SIM interface signals consist of four signals that are UIM_PWR, UIM_RST, UIM_CLK, and UIM_DATA (UIM_Vpp is neither connected nor used in many applications). Due to the relatively low clock frequencies involved, the concern is not the degradation of the SIM signals but that of routing of the SIM interface signals through areas considered to be of high risk for RF noise coupling (crosstalk and RF contamination), which can desensitize the radio circuitry. The general guidelines that should be followed are listed as follows:

  - It is recommended that these signals should be routed over a continuous ground plane.
  - SIM interface signals should not be routed near high transient signals (power supply chokes and DC/DC switching FETs).
  - Prevent routing of these signals near output connectors.
  - Keep SIM interface signals isolated from other signals. 2x width spacing (1.5x min) between SIM interface signals and all other signal routing is recommended.

3.6.3 Certification Test

Using test equipment simulates a (U)SIM card to test U(SIM) protocol in GCF or PTCRB test, If some test. If you encounter some issues during SIM/USIM test, please contact Huawei for more details.

3.7 W_DISABLE# Signal

The W_DISABLE# signal is provided to allow users to disable wireless communications add-in cards. When the W_DISABLE# signal is asserted, all radios should be disabled. When the W_DISABLE# signal is not asserted, the radio may transmit signals if it is not disabled by other means such as software.

The W_DISABLE# signal is an active low signal with internal 100 kΩ pull-up resistor that disables radio operation when being asserted (driven low) by the system.

The combination of the software state and W_DISABLE# assertion state must be determined before the normal operation is resumed. Table 3-10 lists this requirement for W_DISABLE# and the software control setting. For example, the radio RF operation remains disabled unless both the hardware and software are set to enable the RF features of the card.

Table 3-9 W_DISABLE_N signal

Pins	Name	Description	Direction to Module
20	W_DISABLE_N	Close wireless communications	Input

Table 3-10 Radio operational states

W_DISABLE#	SW Control Setting*	Radio Operation
High	Enabled	Enabled
High	Disabled	Disabled
Low	Enabled	
Low	Disabled	

* This control setting is implementation specific; this column represents the collective intention of the host software to manage radio operation.

NOTE

- If you do not turn off the radio manually, the radio will be on when the module is powered on.
- End users need to turn off the radio in some situations such as when being on an airplane.
- According to Mini-PCIE specification, the radio must be turned off through hardware or software. Nearly all PC companies comply with this specification.

3.8 LED_WWAN# Signal

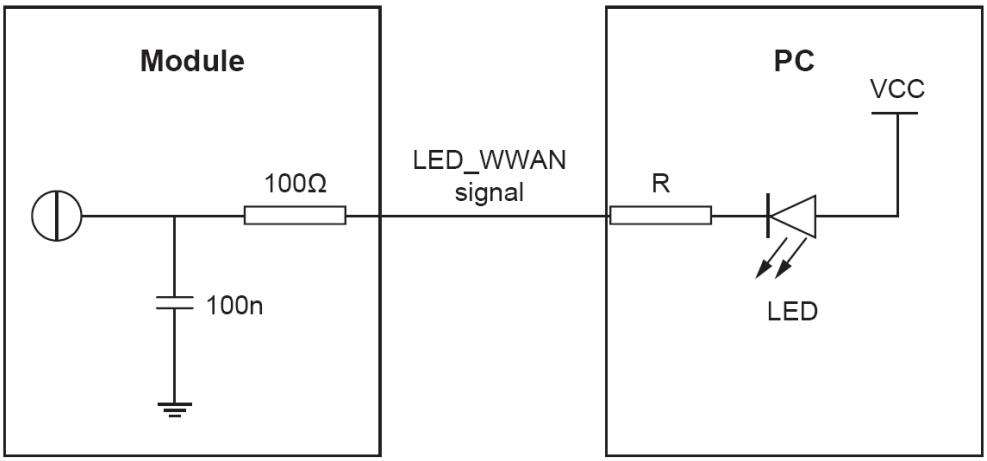
The LED_WWAN signal of the EM820W can allow the voltage of 3.3 V and absorb the current from 5 mA to 40 mA. According to the given circuit, in order to reduce the current of the LED, a resistance of 1 kΩ must be placed in series with the LED.

Table 3-11 LED_WWAN signal

Pins	Name	Description	Additional Description	Direction to Module
42	LED_WWAN	Active-low LED signal indicating the status of the module.	L: Light on H: Light off	Output

This signal is used to display the state of WWAN. The reference circuit diagram is shown in the following figure.

Figure 3-4 LED_WWAN# signal reference circuit diagram



NOTE
Normally, when the HUAWEI module is enabled, the LED is on, and when disabled, the LED is off. The wink mode of the LED can be customized according to the requirement of the client.

For resistance of R placed on PC, choose the value that satisfies the following equation:

IF*R+VF+IF*100 =VCC

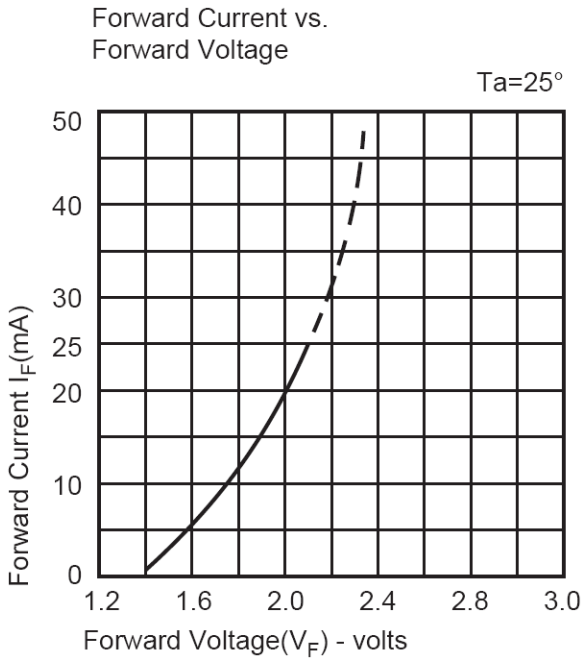
VF: Forward Voltage

IF: Forward current

Take the LED 19-213/GVC-AMNB/3T as an example (its manufacturer is Everlight Electronics., Ltd. and the website is http://www.everlight.com). Figure 3-5 shows its I_F-V_F curves. If VCC is 3.3 V and the desired current through the LED I_F is 3 mA, then the voltage of the LED V_F is 1.5 V. According to I_F-V_F curves, the corresponding value for resistance of R is (3.3 - 0.003 x 100 - 1.5) / 0.003 = 500 Ω.

The brightness of the LED depends on the current value, and for most of the indicator lights the current between 2 mA to 5 mA is adequate.

Figure 3-5 LED typical electro-optical characteristics curves



3.9 WAKE_NB_N Signal

WAKE_NB_N (signal that the module uses to activate the PC)

Support software controls the signal (WAKE_NB_N) that the module uses to activate the PC. This signal is used for 3G module to wake up the host. It's designed as a OC gate, so it should be pulled up by the host and it's active-low.

3.10 NC Pins

The NC pins are not internally connected in the EM820W.

4 RF Specifications

4.1 Operating Frequencies

Table 4-1 shows the RF bands supported by EM820W.

Table 4-1 RF bands

Operating Band	Tx	Rx
UMTS 2100 (Band I)	1920–1980 MHz	2110–2170 MHz
UMTS 1900 (Band II)	1850–1910 MHz	1930–1990 MHz
UMTS 900 (Band VIII)	880–915 MHz	925–960 MHz
UMTS 850(Band V)	824–849MHz	869–894 MHz
GSM 850	824–849 MHz	869–894 MHz
GSM 900	880–915 MHz	925–960 MHz
GSM 1800(DCS)	1710–1785 MHz	1805–1880 MHz
GSM 1900(PCS)	1850–1910 MHz	1930–1990 MHz

4.2 Conducted RF Measurement

4.2.1 Test Environment

Test instrument: R&S CMU200

Power supply: KEITHLEY 2306

RF cable for testing:

L08-C014-350 of DRAKA COMTEQ or Rosenberger

Cable length: 29 cm

Compensation for WCDMA 850 MHz or 900 MHz: 0.6 dB

Compensation for WCDMA 2100 MHz or WCDMA 1900 MHz: 0.8 dB

NOTE
The compensation for different frequency bands relates to the cable and the test environment. The instrument compensation needs to be set according to the actual cable conditions.

4.2.2 Test Standards

Huawei modules meet all 3GPP test standards relating to both 2G and 3G. Each module has passed stringent tests in the factory, thus the quality of the modules is guaranteed.

4.3 Conducted Rx Sensitivity and Tx Power

4.3.1 Conducted Receive Sensitivity

The conducted receive sensitivity is a key parameter that indicates the receiver performance of EM820W. The conducted receive sensitivity means the weakest signal that the module at the antenna port can receive. The BER must meet the 3GPP protocol requirements in the case of the minimum signal.

The 3GPP Protocol Claim column in Table 4-2 lists the required minimum values, and the Test Value column lists the tested values of EM820W.

Table 4-2 EM820W conducted Rx sensitivity

Item		3GPP Protocol Claim (dBm)	EM820W Test Value (dBm)		
			Min	Type	Max
GSM850	GMSK(BER <2.43%)	< -102	-	-109	-107
	8PSK(MCS5, BLER<10%)	< -98	-	-103.5	-101
GSM900	GMSK(BER <2.43%)	< -102	-	-109	-107
	8PSK(MCS5, BLER<10%)	< -98	-	-103.5	-101
GSM1800	GMSK(BER <2.43%)	< -102	-	-109	-107
	8PSK(MCS5, BLER<10%)	< -98	-	-102.5	-100
GSM1900	GMSK(BER <2.43%)	< -102	-	-109	-107
	8PSK(MCS5, BLER<10%)	< -98	-	-102.5	-100
BandI (BER<0.1%)		< -106.7	-	-110	-108

Item	3GPP Protocol Claim (dBm)	EM820W Test Value (dBm)		
		Min	Type	Max
BandII (BER<0.1%)	< -104.7	-	-110	-108
Band VIII (BER<0.1%)	< -103.7	-	-110	-108
Band V (BER<0.1%)	< -104.7	-	-110	-108

NOTE
The test values are the average of some test samples.

4.3.2 Conducted Transmit Power

The conducted transmit power is another indicator that measures the performance of EM820W. The conducted transmit power means the maximum power that the module tested at the antenna port can transmit. According to the 3GPP protocol, the required transmit power varies with the power class.

Table 4-3 lists the required ranges of the conducted transmit power of EM820W. The tested values listed in the Test Value column must be within the range from the minimum power to the maximum power.

Table 4-3 EM820W conducted Tx power

Item		3GPP Protocol Claim (dBm)	EM820W Test Value (dBm)		
			Min	Type	Max
GSM850	GMSK(1Tx Slot)	31~35	31.5	32.5	33.5
	8PSK(1Tx Slot)	24~30	26	27	28
GSM900	GMSK(1Tx Slot)	31~35	31.5	32.5	33.5
	8PSK(1Tx Slot)	24~30	26	27	28
GSM1800	GMSK(1Tx Slot)	28~32	28.5	29.5	30.5
	8PSK(1Tx Slot)	23~29	25	26	27
GSM1900	GMSK(1Tx Slot)	28~32	28.5	29.5	30.5
	8PSK(1Tx Slot)	23~29	25	26	27
Band I(W2100)		21~25	22.5	23.5	24.5
Band II(W1900)		21~25	22.5	23.5	24.5
Band VIII(W900)		21~25	22.5	23.5	24.5
Band V(W850)		21~25	22.5	23.5	24.5

4.4 Antenna Design Requirements

4.4.1 Antenna Design Indicators

Antenna Efficiency

Antenna efficiency is the ratio of the input power to the radiated or received power of an antenna. The radiated power of an antenna is always lower than the input power due to the following losses: return loss, material loss, and coupling loss. The efficiency of an antenna relates to its electrical dimensions. To be specific, the antenna efficiency increases with the electrical dimensions. In addition, the transmission cable from the antenna port of the EM820W to the antenna is also part of the antenna. The cable loss increases with the cable length and the frequency. It is recommended that the cable loss should be as low as possible, for example, U.FL-LP-088 made by HRS.

The following antenna efficiency (free space) is recommended for the EM820W on a laptop to ensure high radio performance of the EM820W:

- Efficiency of the master antenna > 40% (-4 dB)
- Efficiency of the slave antenna > 40% (-4 dB)
- Efficiency of the GPS antenna > 50% (-3 dB)
- Efficiency of the Wi-Fi antenna > 40% (-4 dB)

Isolation

For a wireless device with multiple antennas, the power of different antennas is coupled with each other. Antenna isolation is used to measure the power coupling. The power radiated by an antenna might be received by an adjacent antenna, which decreases the antenna radiation efficiency and affects the running of other devices. To avoid this problem, evaluate the antenna isolation as sufficiently as possible at the early stage of antenna design.

Antenna isolation depends on the following factors:

- Distance between antennas
- Antenna type
- Antenna direction

The master antenna must be placed as near as possible to the EM820W to minimize the cable length. The slave antenna needs to be installed perpendicularly to the master antenna. The slave antenna can be placed farther away from the EM820W. Antenna isolation can be measured with a two-port vector network analyzer.

The following antenna isolation is recommended for the antennas on laptops:

- Isolation between master and slave antennas < -12 dB
- Isolation between the master antenna and the GPS antenna < -15 dB
- Isolation between the slave antenna and the Wi-Fi antenna < -15 dB

If a Wi-Fi module is installed on the laptop, the following measures must be taken to reduce mutual influence between the data card module and the Wi-Fi module:

- Adding a bandpass filter to the Wi-Fi channel to filter the WCDMA, GSM850, GSM900, DCS, and PCS signals
- Ensuring sufficient isolation between the master antenna of the data card module and the Wi-Fi antenna

Table 4-4 lists the requirements for the isolation between the master antenna and the Wi-Fi antenna in different frequency bands according to the interference suppression supported by the filter in different frequency bands.

Table 4-4 Isolation between the master antenna and the Wi-Fi antenna

Frequency Band	Transmit Frequency	Conducted Transmit Power (dBm)	Ant Isolator (dB)	Wi-Fi Front End Filter Attenuation (dB)
UMTS2100	1920–1980 MHz	24	11	34
UMTS1900	1850–1910 MHz	24	11	34
UMTS850	824–849 MHz	24	10	36
UMTS900	880–915 MHz	24	10	36
GSM850	824–849 MHz	33	18	36
GSM900	880–915 MHz	33	18	36
DCS	1710–1785 MHz	30	17	34
PCS	1850–1910 MHz	30	17	34

S11 or VSWR

S11 (return loss) indicates the degree to which the input impedance of an antenna matches the reference impedance (50 ohm). S11 shows the resonance feature and impedance bandwidth of an antenna. Voltage standing wave ratio (VSWR) is another expression of S11. S11 relates to the antenna efficiency. S11 can be measured with a vector analyzer.

The following S11 values are recommended for the antennas on laptops:

- S11 of the master antenna < -6 dB
- S11 of the slave antenna < -6 dB
- S11 of the GSP antenna < -10 dB
- S11 of the Wi-Fi antenna < -10 dB

Polarization

The polarization of an antenna is the orientation of the electric field vector that rotates with time in the direction of maximum radiation.

The linear polarization is recommended for the antennas on laptops.

Envelope Correlation Coefficient

The envelope correlation coefficient indicates the correlation between different antennas in a multi-antenna system (master antenna, diversity antenna, and MIMO antenna). The correlation coefficient shows the similarity of radiation patterns, that is, amplitude and phase, of the antennas. The ideal correlation coefficient of a diversity antenna system or a MIMO antenna system is 0. A small value of the envelope correlation coefficient between the master antenna and the slave antenna indicates a high diversity gain. The envelope correlation coefficient depends on the following factors:

- Distance between antennas
- Antenna type
- Antenna direction

The antenna correlation coefficient differs from the antenna isolation. Sufficient antenna isolation does not represent a satisfactory correlation coefficient. For this reason, the two indicators need to be evaluated separately.

For the antennas on laptops, the recommended envelope correlation coefficient between the master antenna and the diversity antenna is smaller than 0.5.

Radiation Pattern

The radiation pattern of an antenna reflects the radiation features of the antenna in the remote field region. The radiation pattern of an antenna describes the power or field strength of the radiated electromagnetic waves in various directions from the antenna. The power or field strength varies with the angular coordinates (θ and φ), but is independent of the radial coordinates.

The radiation pattern of half wave dipole antennas is the best option for wireless terminals. The radiation pattern of half wave dipole antennas is omnidirectional in the horizontal plane, and the incident waves of base stations are often in the horizontal plane. For this reason, the reception is optimal.

To improve the performance of diversity antennas, it is recommended that the radiation pattern of the slave antenna be complementary with that of the master antenna.

The following radiation patterns are recommended for the antennas on laptops:

- Master antenna: omnidirectional
- Slave antenna: complementary with the radiation pattern of the master slave
- GPS antenna: omnidirectional
- Wi-Fi antenna: omnidirectional

Gain and Directivity

The radiation pattern of an antenna represents the field strength of the radiated electromagnetic waves in all directions, but not the power density that the antenna radiates in the specific direction. The directivity of an antenna, however, measures the power density that the antenna radiates.

Gain, as another important parameter of antennas, correlates closely to the directivity. The gain of an antenna takes both the directivity and the efficiency of the antenna

into account. The appropriate antenna gain prolongs the service life of relevant batteries.

The following antenna gain is recommended for antennas on laptops:

- Gain of the master antenna ≤ 3 dBi
- Gain of the slave antenna ≤ 3 dBi

NOTE

- The antenna on a laptop consists of the antenna body and the relevant RF transmission cable. Take the RF transmission cable inside the laptop into account when measuring any of the preceding antenna indicators.
- Huawei cooperates with various antenna suppliers who are able to make suggestions on antenna design, for example, Amphenol, Skycross, Pulse etc.

4.4.2 Interference

Besides the antenna performance, the interference on the user board also affects the radio performance (especially the TIS) of the module. To guarantee high performance of the module, the interference sources on the user board must be properly controlled.

On the user board, there are various interference sources, such as the LCD, CPU, audio circuits, and power supply. All the interference sources emit interference signals that affect the normal operation of the module. For example, the module sensitivity can be decreased due to interference signals. Therefore, during the design, you need to consider how to lessen the effects of interference sources on the module. To lessen the effects of interference sources on the module, you can use an LCD with optimized performance, shield the LCD interference signals, shield the signal cable of the board, or design filter circuits.

Huawei is capable of making technical suggestions on radio performance improvement of the module.

4.4.3 GSM/WCDMA Antenna Requirements

The antenna for EM820W must fulfill the following requirements:

Table 4-5 GSM/WCDMA antenna requirements

GSM/WCDMA Antenna Requirements	
Frequency range	Depending on the frequency band(s) provided by the network operator, the customer must use the most suitable antenna for that/those band(s)

GSM/WCDMA Antenna Requirements	
Bandwidth	70 MHz in GSM850 80 MHz in GSM900 170 MHz in DCS 140 MHz PCS 70 MHZ in WCDMA850 80 MHz in WCDMA900 140 MHz in WCDMA1900 250 MHz in WCDMA2100 band
Gain	Gain < 3dBi
Impedance	50 Ohm
Input power	> 33dBm(2 W) peak power in GSM > 24dBm Average power in WCDMA
VSWR absolute max	<= 10:1
VSWR recommended	<= 2:1

Furthermore, if the device is developed for US and/or Canada market, it must comply with the FCC and/or IC approval requirements:

This device is to be used only for mobile and fixed application. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. End-Users must be provided with transmitter operation conditions for satisfying RF exposure compliance. OEM integrators must ensure that the end user has no manual instructions to remove or install the UC864-E/G/WD /WDU module. Antennas used for this OEM module must not exceed 3dBi gain for mobile and fixed operating configurations.

4.4.4 Radio Test Environment

The antenna efficiency, antenna gain, radiation pattern, total radiated power (TRP), and TIS can be tested in a microwave testing chamber.

Huawei has a complete set of OTA test environment (SATIMO microwave testing chambers and ETS microwave testing chambers). The testing chambers are certified by professional organizations and are applicable to testing at frequencies ranging from 380 MHz to 6 GHz. The test items are described as follows:

Passive Tests

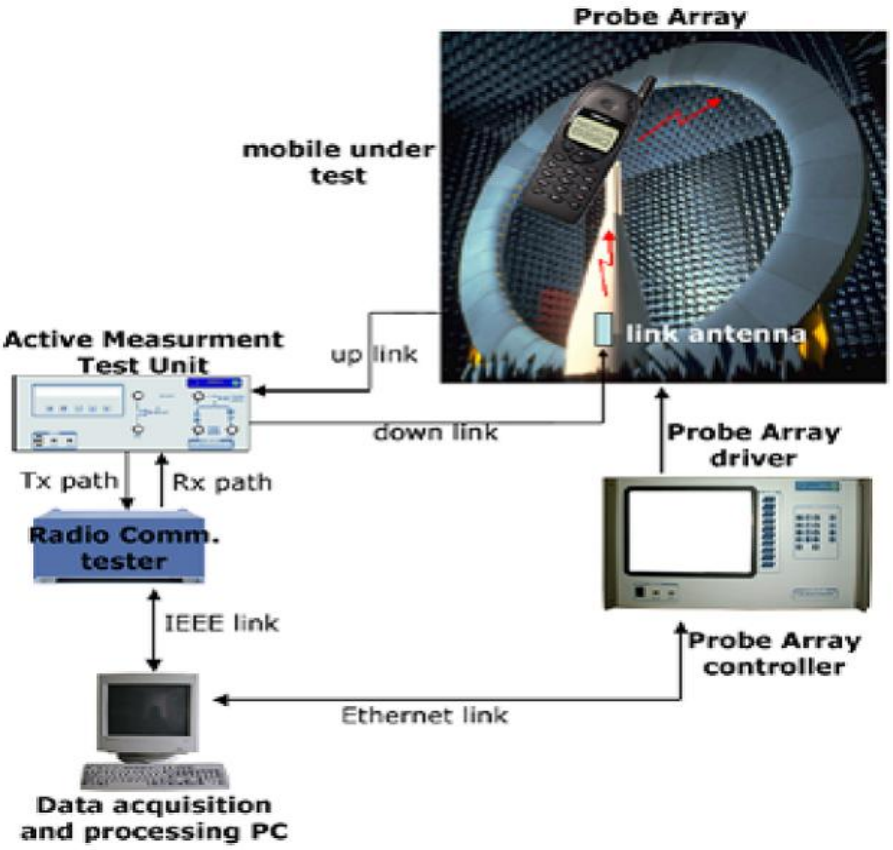
- Antenna efficiency
- Gain
- Pattern shape
- Envelope correlation coefficient

Active Tests

- TRP: GSM, WCDMA, CDMA, TD-SCDMA, and LTE systems
- TIS: GSM, WCDMA, CDMA, TD-SCDMA, and LTE systems

Figure 4-1 shows the SATIMO microwave testing chamber.

Figure 4-1 SATIMO microwave testing chamber



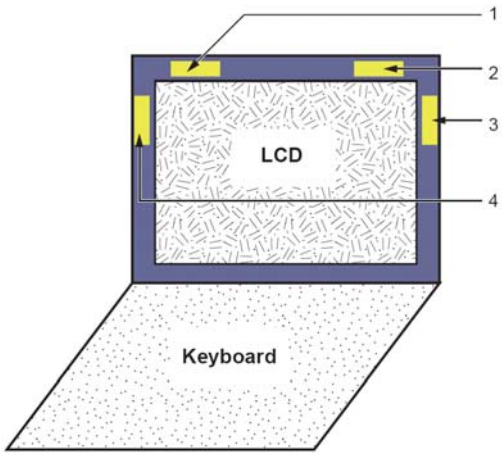
4.5 Design Recommendations

4.5.1 Recommendations for Designing the Module Antennas

The design recommendations are as follows:

- It is recommended that the module antennas are designed at the upper edge, left edge, or right edge of the laptop screen. Designing the antenna at the upper edge is better.
- Take the isolation and envelope correlation between the master antenna and the slave antenna into account when designing the antennas. Keep the slave antenna away from the master antenna as far as possible. Install the slave antenna perpendicularly to the master slave. See Figure 4-2, Install the master and slave antennas in positions 1 and 3 or 2 and 4 but not in positions 1 and 2 or 3 and 4.

Figure 4-2 Recommended antenna positions



- It is recommended that the antenna pattern be designed based on the horizontal polarized omnidirectional pattern that facilitates the reception of strong signals especially in outdoor environments.
- Besides the module antennas, a laptop has other internal antennas, such as the WLAN antenna. Therefore, when designing the module antennas, the requirement on the isolation between module antennas and other laptop antennas should be considered. Ensure that proper distance is maintained between antennas if possible. To reduce the interference between antennas, it is recommended that an antenna is not designed close to another one.
- Carefully design the metallic components (such as the external frame of the metallic shell) in and near the antenna area by considering the effects on the antenna performance (such as whether the frequency offset of the antenna occurs and whether the antenna pattern is deformed).

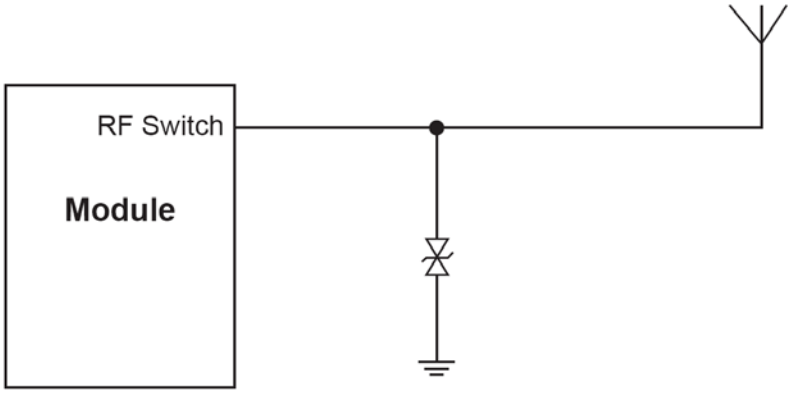
4.6 ESD Protection for the Antenna Interface

WARNING

In practical application, pay attention to the ESD protection for the antenna interface of the EM820W module. Incorrect operation may result in permanent damage to the RF components.

Figure 4-3 shows the ESD protection circuit recommended for the antenna interface.

Figure 4-3 ESD protection circuit recommended for the antenna interface



CAUTION

It is recommended that you pay attention to the junction capacitance of the TVS diode when you choose the model of the TVS diode. Ensure that the junction capacitance of the TVS diode is lower than 1 pF.

5 Electrical and Reliability Features

5.1 About This Chapter

This chapter describes the electrical and reliability features of the interfaces in the EM820W module, including:

- Extreme Working Conditions
- Working and Storage Temperatures and Humidity
- Electrical Criteria of Application Interfaces
- Power Supply Features
- Reliability Features
- EMC and ESD Features

5.2 Extreme Working Conditions

WARNING

Table 5-1 lists the extreme working conditions for the EM820W module. Using the EM820W module beyond these conditions may result in permanent damage to the module.

5.3 Working and Storage Temperatures and Humidity

Table 5-1 lists the working and storage temperatures and humidity for the EM820W module.

Table 5-1 Working and storage temperatures and humidity for the EM820W module

Specification	Minimum Value	Maximum Value	Unit
Normal working temperatures [1]	–10	+55	°C
Extreme working temperatures [2]	–20 to –10	+55 to +70	°C
Ambient temperature for storage	–40	+85	°C
Moisture	5	95	%

NOTE

[1]: When the EM820W module works at this temperature, all its RF indexes comply with the 3GPP TS 45.005 specifications.

[2]: When the EM820W module works at this temperature, certain RF indexes do not comply with the 3GPP TS 45.005 specifications.

5.4 Electrical Criteria of Application Interfaces

Table 5-2 lists electrical features (typical values)

Table 5-2 Electrical features of application interfaces

Parameter	Description	Minimum Value	Maximum Value	Unit
V_{IH}	High-level input voltage	0.65*V_{DD_PX}	V_{DD_PX} +0.3	V
V_{IL}	Low-level input voltage	–0.3	0.35* V_{DD_PX}	V
I_{leak}	Input leakage current	–0.2	0.2	uA
V_{OH}	High-level output voltage	V_{DD_PX} –0.45	V_{DD_PX}	V
V_{OL}	Low-level output voltage	0	0.45	V
I_{OH}	High-level output current	1.5	-	mA
I_{OL}	Low-level output current	-	–1.5	mA

5.5 Power Supply Features

5.5.1 Power Supply

The EM820W receives its power supply from a 3.3 V power source, which must satisfy all requirements of PCI Express Mini CEM specifications, such as voltage tolerance and peak and normal current. The detailed requirements are listed in Table 5-3.

Table 5-3 Power requirements

Power	Voltage Tolerance	Peak (Maximum)	Normal (Maximum)
3.3 V	±9%	2750 mA	1100 mA

NOTE

In burst transmit mode of GSM/GPRS/EDGE, the instantaneous current of the module will exceed 2.75 A, which will pull down the power voltage transitorily and perhaps result in the reset of the module or host. In order to prevent this situation, you can add a large bulk capacitor beside the module on the host side (at least two 330uF capacitors).

5.5.2 Power Consumption

The power consumptions of the EM820W in different scenarios are listed in Table 5-4, Table 5-5 and Table 5-6 respectively.

Table 5-4 DC power consumption (HSPA/WCDMA)

Description	Band	Test Value	Units	Power (dBm)
WCDMA	Band I	284	mA	1 dBm Tx Power
		336		10 dBm Tx Power
		544		24 dBm Tx Power
	Band II	289	mA	1 dBm Tx Power
		340		10 dBm Tx Power
		606		24 dBm Tx Power
	Band V	293	mA	1 dBm Tx Power
		317		10 dBm Tx Power
		501		24 dBm Tx Power
	Band VIII	291	mA	1 dBm Tx Power
		310		10 dBm Tx Power
		517		24 dBm Tx Power

Description	Band	Test Value	Units	Power (dBm)
HSDPA	Band I	348	mA	1 dBm Tx Power
		395		10 dBm Tx Power
		585		24 dBm Tx Power
	Band II	350	mA	1 dBm Tx Power
		409		10 dBm Tx Power
		646		24 dBm Tx Power
	Band V	361	mA	1 dBm Tx Power
		380		10 dBm Tx Power
		552		24 dBm Tx Power
	Band VIII	343	mA	1d Bm Tx Power
		365		10 dBm Tx Power
		560		24 dBm Tx Power
HSUPA	Band I	378	mA	1 dBm Tx Power
		424		10 dBm Tx Power
		610		24 dBm Tx Power
	Band II	357	mA	1 dBm Tx Power
		407		10 dBm Tx Power
		643		24 dBm Tx Power
	Band V	363	mA	1 dBm Tx Power
		381		10 dBm Tx Power
		524		24 dBm Tx Power
	Band VIII	361	mA	1d Bm Tx Power
		382		10 dBm Tx Power
		531		24 dBm Tx Power

Table 5-5 DC power consumption (GSM/GPRS/EDGE)

Description	Test Value	Units	PCL	Configuration
GPRS850	346	mA	5	1 Up/1 Down
	513			2 Up/1 Down
	160	mA	15	1 Up/1 Down

Description	Test Value	Units	PCL	Configuration
	225			2 Up/1 Down
GPRS900	345	mA	5	1 Up/1 Down
	514			2 Up/1 Down
	143	mA	15	1 Up/1 Down
	195			2 Up/1 Down
GPRS1800	236	mA	0	1 Up/1 Down
	355			2 Up/1 Down
	128	mA	10	1 Up/1 Down
	166			2 Up/1 Down
GPRS1900	217	mA	0	1 Up/1 Down
	318			2 Up/1 Down
	131	mA	10	1 Up/1 Down
	167			2 Up/1 Down
EDGE850	250	mA	8	1 Up/1 Down
	351			2 Up/1 Down
	488			4 Up/1 Down
	165	mA	15	1 Up/1 Down
	217			2 Up/1 Down
	293			4 Up/1 Down
EDGE900	229	mA	8	1 Up/1 Down
	329			2 Up/1 Down
	468			4 Up/1 Down
	142	mA	15	1 Up/1 Down
	193			2 Up/1 Down
	270			4 Up/1 Down
EDGE1800	192	mA	2	1 Up/1 Down
	265			2 Up/1 Down
	362			4 Up/1 Down
	128	mA	10	1 Up/1 Down
	165			2 Up/1 Down
	210			4 Up/1 Down

Description	Test Value	Units	PCL	Configuration
EDGE1900	194	mA	2	1 Up/1 Down
	257			2 Up/1 Down
	341			4 Up/1 Down
	142	mA	10	1 Up/1 Down
	177			2 Up/1 Down
	218			4 Up/1 Down

Table 5-6 DC power consumption(Idle and Suspend)

Scenario	Idle		Suspend		Unit
	Offline Enabled	Offline Disabled	Offline Enabled	Offline Disabled	
WCDMA 2100MHz DRX = 8 (2.56 s)	66.3	72.7	4.1	5.8	mA
GSM 900MHz MFRM = 5 (1.18 s)	70.6	73.1	4.1	7.8	mA

NOTE

- In idle mode, the module is registered to the network, USB bus is active, and no voice or data call connection is ongoing.
- The above values are the average of some test samples.

5.6 Reliability Features

Table 5-7 lists the test conditions and results of the mechanical reliability of the EM820W module.

Table 5-7 Test conditions and results of the mechanical reliability of the EM820W module

Item	Test Condition	Standard
Low-temperature storage	Temperature: –40±2ºC Test duration: 24 h	IEC60068
High-temperature storage	Temperature: 85±2ºC Test duration: 24 h	IEC60068

Item	Test Condition	Standard
Low-temperature working	Temperature: –30±2ºC Test duration: 24 h	IEC60068
High-temperature working	Temperature: 75±2ºC Test duration: 24 h	IEC60068
Damp heat cycling	High temperature: 55±2ºC Low temperature: 25±2ºC Humidity: 95% Repetition times: 4 Test duration: 12 h + 12 h	IEC60068
Temperature shock	Low temperature: –40±2ºC High temperature: 85±2ºC Temperature change interval: < 30s Test duration: 15 min Repetition times: 100	IEC60068
Salty fog test	Temperature: 35°C Density of the NaCl solution: 5±1% Spraying interval: 8 h Duration of exposing the module to the temperature of 35°C: 16 h	IEC60068
Sine vibration	Frequency range: 5 Hz to 200 Hz Acceleration: 10 m/s2 Frequency scan rate: 1 oct/min Test period: 3 axial directions. Five circles for each axial direction.	IEC60068
Shock test	Half-sine wave shock Peak acceleration: 300 m/s2 Shock duration: 11 ms Test period: 6 axial directions. One shock for each axial direction.	IEC60068
Clash test	Half-sine wave Peak acceleration: 180 m/s2 Pulse duration: 6 ms Repetition time: 6 directions. 1000 times for each direction.	IEC60068

Item	Test Condition	Standard
Drop test	First case: 0.3 m in height. Drop the EM820W module on the marble terrace with one surface facing downwards twice. Six surfaces should be tested. Second case: 0.8 m in height. Drop the EM820W module on the marble terrace with one surface facing downwards twice. Six surfaces should be tested.	IEC60068

5.7 EMC and ESD Features

EMC tests have to be performed on the application as soon as possible to detect any potential problems.

When designing, special attention should be paid to:

- Possible spurious emissions radiated by the application to the RF receiver in the receiver band.
- ESD protection that is mandatory on all signals which are externally accessible

  Typically, ESD protection is mandatory for the:
  - SIM (if accessible from outside)
  - Serial link
- Length of the SIM interface lines (preferably <10cm).
- EMC protection on audio input/output (filters against 900MHz emissions).
- Biasing of the microphone inputs.
- Ground plane: HUAWEI Wireless recommends a common ground plane for analog/digital/RF grounds.
- A metallic case or plastic casing with conductive paint is recommended, except for areas around the antenna.

NOTE
The HUAWEI EM820W Embedded Module does not include any protection against high voltage.

6 Mechanical Specifications

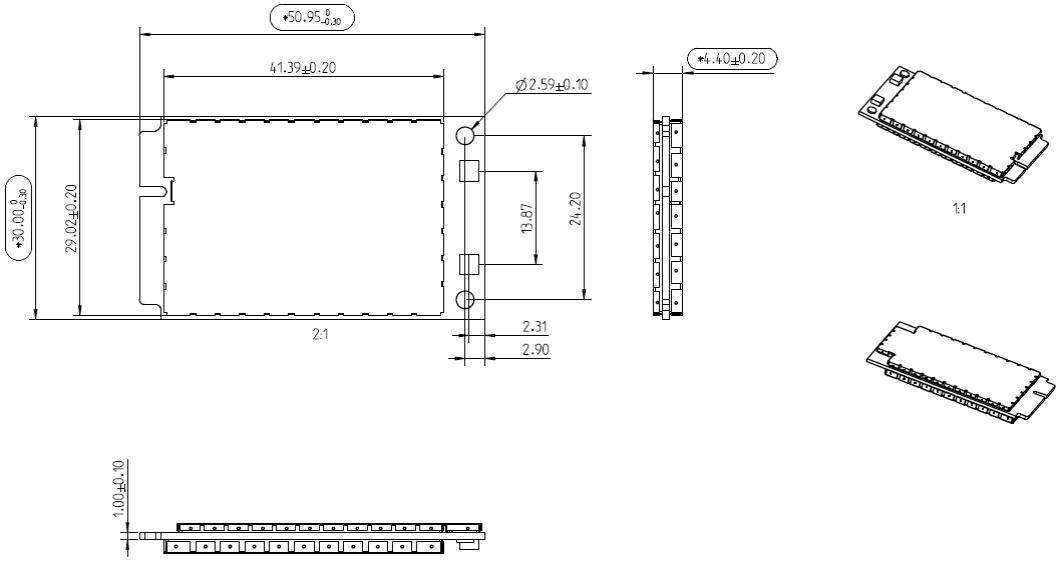
6.1 Dimensions and Interfaces

6.1.1 Dimensions and Interfaces of EM820W

The dimensions of EM820W are 50.95 mm (length) × 30 mm (width) × 4.5 mm (height). Figure 6-1 shows the dimensions of EM820W in detail.

Figure 6-1 shows the appearance of the interfaces on the EM820W.

Figure 6-1 Dimensions of the EM820W

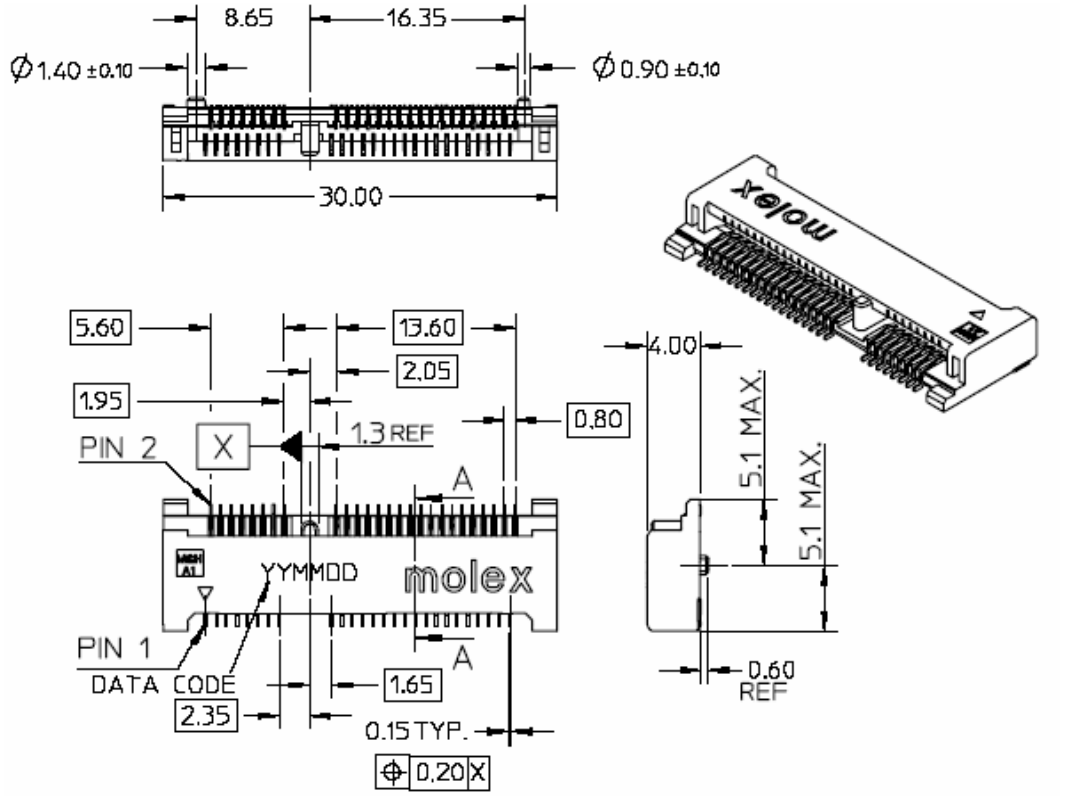


6.2 Dimensions of the Mini PCI Express Connector

The EM820W adopts a standard Mini PCI Express connector that has 52 pins and complies with the *PCI Express Mini Card Electromechanical Specification Revision 1.2*.

Figure 6-2 shows a 52-pin Mini PCI Express connector (take the Molex 67910002 as an example).

Figure 6-2 Dimensions of the Mini PCI Express connector

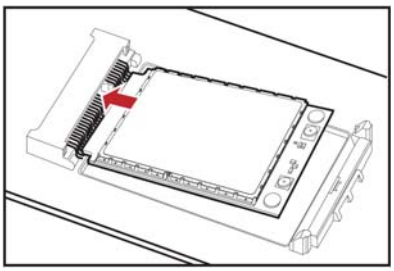


6.3 Specification Selection for Fasteners

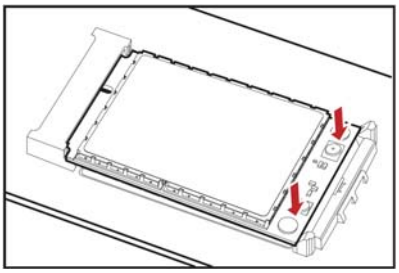
6.3.1 Installing the EM820W on the Main Board of PC

To install the EM820W on the main board of the PC, do the following:

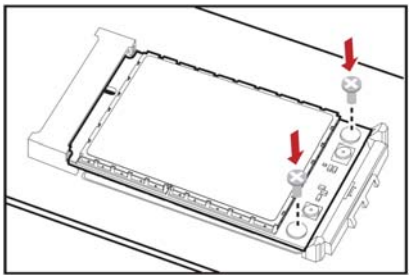
Step 1 Insert the Mini PCI Express connector of the EM820W into the WWAN Mini PCI Express interface on the main board of PC.



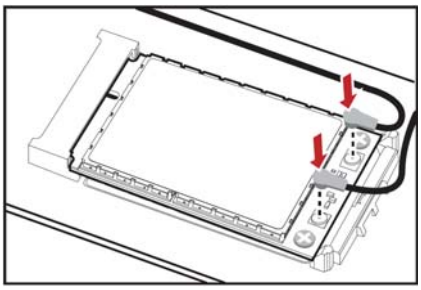
Step 2 Press downwards to fix the EM820W in the module slot.



Step 3 Use a screwdriver to fix the EM820W on the main board of the PC with two screws provided in the EM820W packing box.



Step 4 Insert the connector of the main antenna into the MAIN antenna interface (M) of the EM820W according to the indication on the label of the EM820W. Insert the connector of the auxiliary antenna into the AUX antenna interface (A) of the c EM820W in the same way.

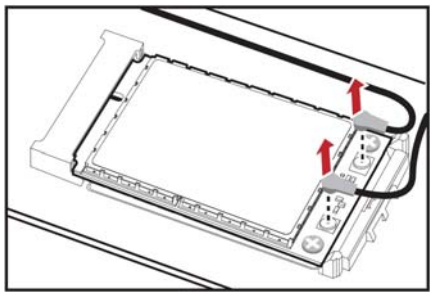


NOTE

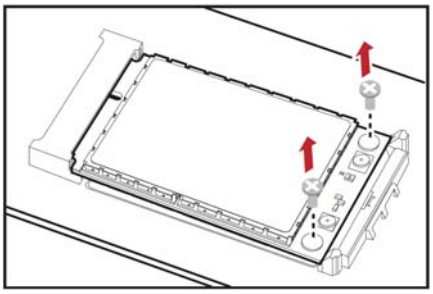
- Insert the antenna connectors vertically into the antenna interfaces of the EM820W.
- Do not press or squeeze the antenna cable or damage the connectors. Otherwise, the wireless performance of the EM820W may be reduced or the EM820W cannot work normally.
- Ensure that the antenna cables are routed through the channel in the frame of the PC and do not lay the cables across the raised edges of the frame.

6.3.2 Romoving the EM820W from the Main Board of PC

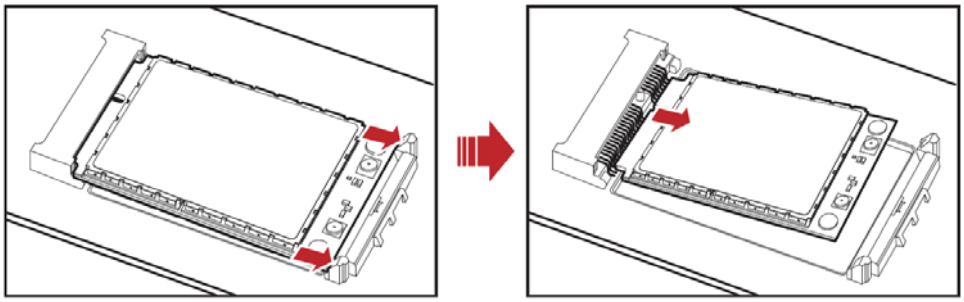
Step 1 Disconnect the antenna cables from the EM820W. You can lift the connectors using a small screwdriver.



Step 2 Remove the two screws with the screwdriver.

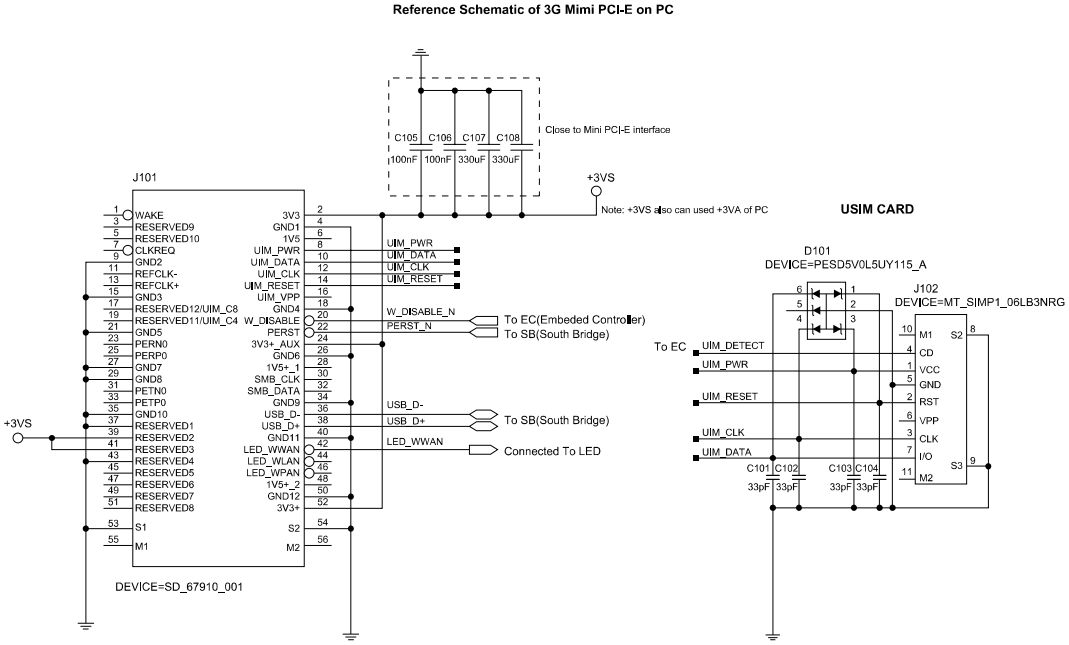


Step 3 Slide backwards the two clips to release the EM820W from the slot. Then, lift up the EM820W.



7 Appendix A Circuits of Typical Interfaces

Figure 7-1 Circuits of typical interfaces in the EM820W module



8 Appendix B Acronyms and Abbreviations

Acronym or Abbreviation	Expansion
BB	Baseband
CE	European Conformity
CS	Coding Scheme
CSD	Circuit Switched Data
DC	direct current
DCE	data circuit-terminating equipment
DMA	direct memory access
DTE	data terminal equipment
EIA	Electronic Industries Association
EMC	electromagnetic compatibility
ESD	electrostatic discharge
EU	European Conformity
FCC	Federal Commnications Commission
FDD-TDMA	frequency division duplexing–time division multiple access
GMSK	Gaussian minimum shift keying
GPRS	general packet radio service
ISO	International Standards Organization
LCP	liquid crystal polyester
LDO	low-dropout
LED	light-emitting diode
MCP	multi-chip package

Acronym or Abbreviation	Expansion
NTC	negative temperature coefficient
PBCCH	Packet Broadcast Control Channel
PCB	printed circuit board
PDU	protocol data unit
PMU	Power manage Unit
RF	radio frequency
RoHS	Restriction of the use of certain Hazardous Substances
RTC	real-time clock
SIM	Subscriber Identity Module
TTL	transistor-transistor logic
TVS	transient voltage suppressor
VSWR	voltage standing wave ratio